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by

L. E. Stipe and J. E. Dewey

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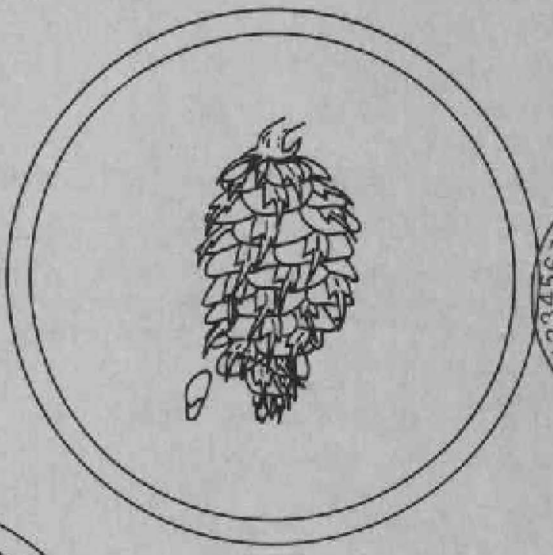

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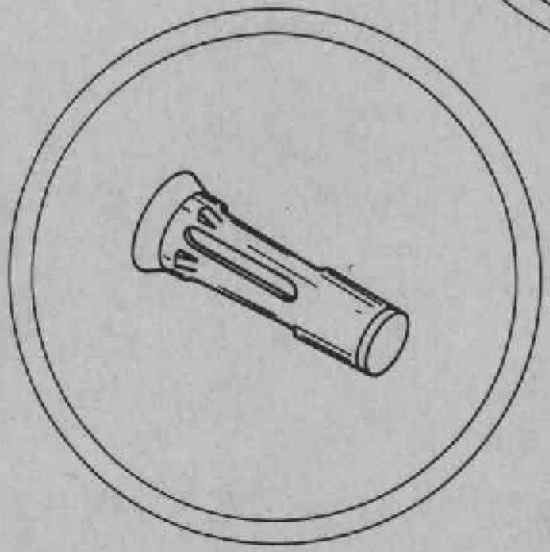

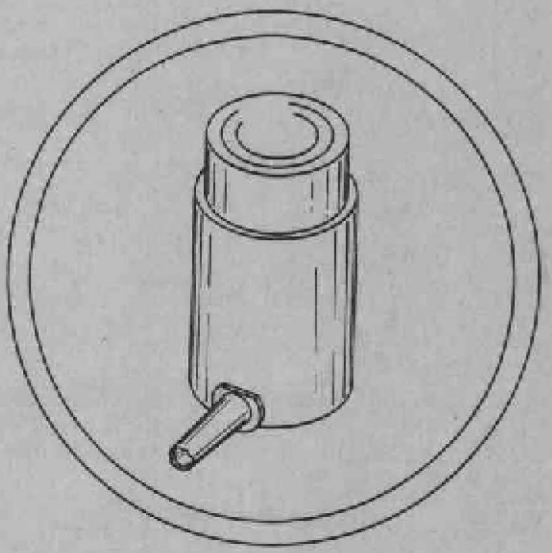

PROTECTING DOUGLAS-FIR CONES AND FOLIAGE WITH A SYSTEMIC INSECTICIDE

by

L. E. Stipe and J. E. Dewey

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ABSTRACT

Trees in a Douglas-fir stand infested with western spruce budworm were treated with a systemic insecticide to protect cone and seed production at three locations in Montana during 1983. Treatments applied were (1) acephate as an Acecap implant, (2) acephate as an Inject-A-Cide injection, and (3) control. Potential cone-bearing trees were selected and then randomly assigned one of the above treatments. Treatments were applied from mid- to late April. Cone buds varied from tight to recently burst. Data collected were as follows: tree heights and diameters, cone damage and infestation rate just after pollination, host tree defoliation from one location, estimate of external damage on mature cones, green cone weight, and seed per cone classified as full, hollow or damaged.

Rates of infestation and damage on the small cones were not different by treatment. Foliage protection was between 56 and 74 percent. External cone damage and cone weights improved with both acephate treatments. Seed yield increased 69 to 82 percent for Acecaps and 65 to 84 percent for Inject-A-Cides. The proportion of full, hollow, and damaged seed did not change between treatments. In budworm-infested Douglas-fir, both Acecaps and Inject-A-Cides are an effective means to improve seed production.

INTRODUCTION

The western spruce budworm, Choristoneura occidentalis Freeman, is a serious pest of Douglas-fir cones in Montana (Dewey 1970). Entire cone crops can be destroyed. Ground spraying techniques have been developed to protect Douglas-fir seed against this insect. Demonstrations have shown that ground spraying with carbaryl or acephate can double seed yield (Stipe and Green 1981; Stipe 1984). Ground spraying can be used where vehicle access is good and weather conditions permit. Even better results were obtained by implanting or injecting systemic insecticides directly into the tree (Reardon 1984). Systemic chemicals, although a little more expensive, can be used under a wider range of site and weather conditions. Equipment needed is portable and can be used in remote areas, and since systemics are carried within a tree's vascular system, no drift or contamination of nontargets occur. This report describes application procedures, sampling techniques and results of a demonstration of the insecticide acephate applied as (1) an implant (Acecap® 97) and (2) an injection (Inject-A-Cide® O).

METHODS

The Montana Douglas-fir cone crop during 1983 was for the most part very small. Extensive searching and bud dissections during March revealed only two areas with enough trees with a potential cone crop to accommodate the sampling requirements of this project. These areas were on the Gallatin National Forest near Gardiner, and the Beaverhead National Forest near Wise River.

In late April, a third area was located on Champion International land near Frenchtown, Montana. This area was discovered only because by this date cone buds had opened and were conspicuous from the ground.

Potential cone-bearing trees were selected at Wise River and Gardiner by cutting upper crown branch tips with a telescopic pole pruner. Buds were examined to estimate the number of potential ovulate cones. Test trees near Frenchtown were selected by visually identifying trees with 25 or more new conelets.

At each location, test trees were randomly assigned one of the following treatments: acephate (powder)/Acecap® 97 (implant); acephate(liquid)/Inject-A-Cide® O (injector); and control. Treatments were applied April 13 at Gardiner, April 17 at Wise River, and April 25 at Frenchtown.

The Acecaps were implanted into the trees by drilling a three-eighth inch diameter hole through the bark and about 1½ inches into the sapwood. The capsules were driven to the bottom of the hole leaving the outer end approximately 1 inch below the bark surface. Implants were applied at 4-inch intervals beginning about 6 to 12 inches above the ground and spiraling around the tree to a height of about 18 inches. Acecaps were used to completely encircle the tree (figure 1).

Inject-A-Cide and feeder tubes were inserted in 11/64-inch holes drilled encircling the tree at a constant height of about 6-12 inches above the ground (figure 2). The feeder tubes were placed at 6-inch intervals and extended approximately one-half inch beyond the cambium into the sapwood.

Although we planned for 20 replications of each treatment at each location, the number of test trees varied due to a shortage of cone-bearing trees and acephate implants. Also, a late killing frost destroyed the cone crop on several test trees near Gardiner between treatment and the first cone sample.

The actual numbers of trees used for our seed yield evaluation by area were:

Treatment	Wise River	Gardiner	Frenchtown
Acecap	13	15	10
Inject-A-Cide	12	13	20
Control	14	16	18

Diameter and height were recorded for all test trees to determine if relationships exist between tree characteristics and cone protection.

An early sample was taken shortly after cones became pendant to assess insect injury while the cones were still small and before they were prematurely cast. On those trees where numbers permitted, 20 cones were collected for laboratory examination. Collections were made May 4 at Frenchtown, May 17 at Gardiner, and June 1 at Wise River. The amount and type of cone damage was recorded.

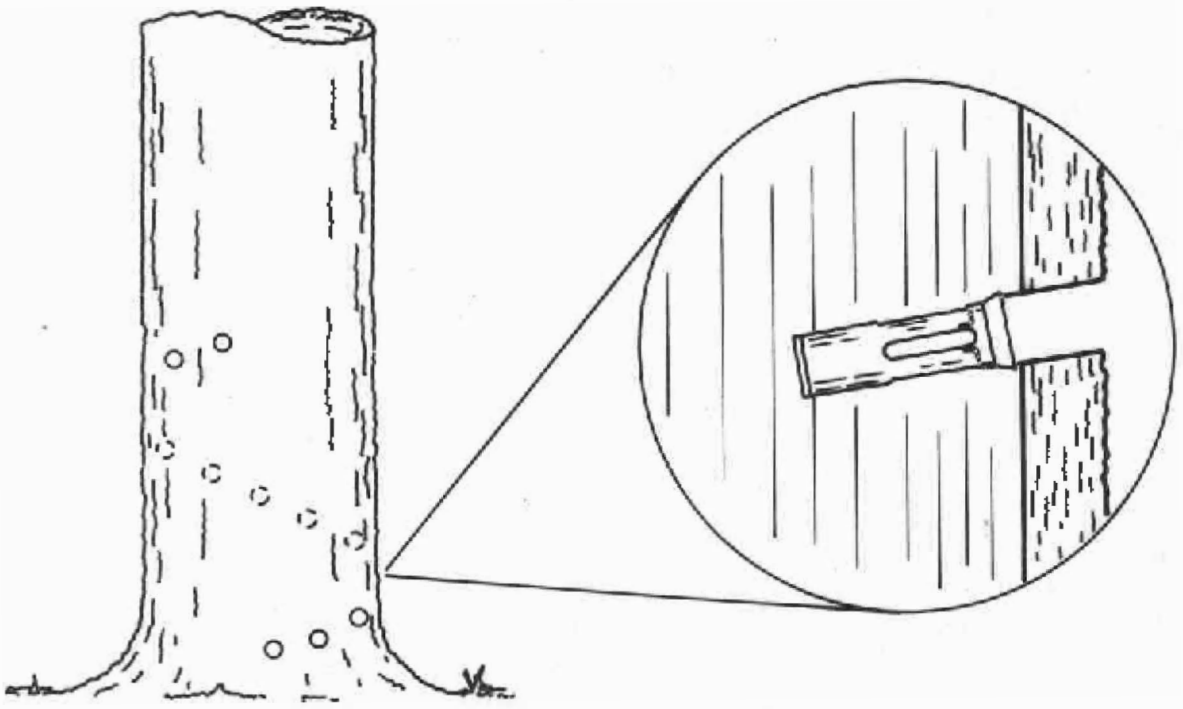

Figure 1. Placement of Acecap implants -- 4-inch spacing on spiral pattern.

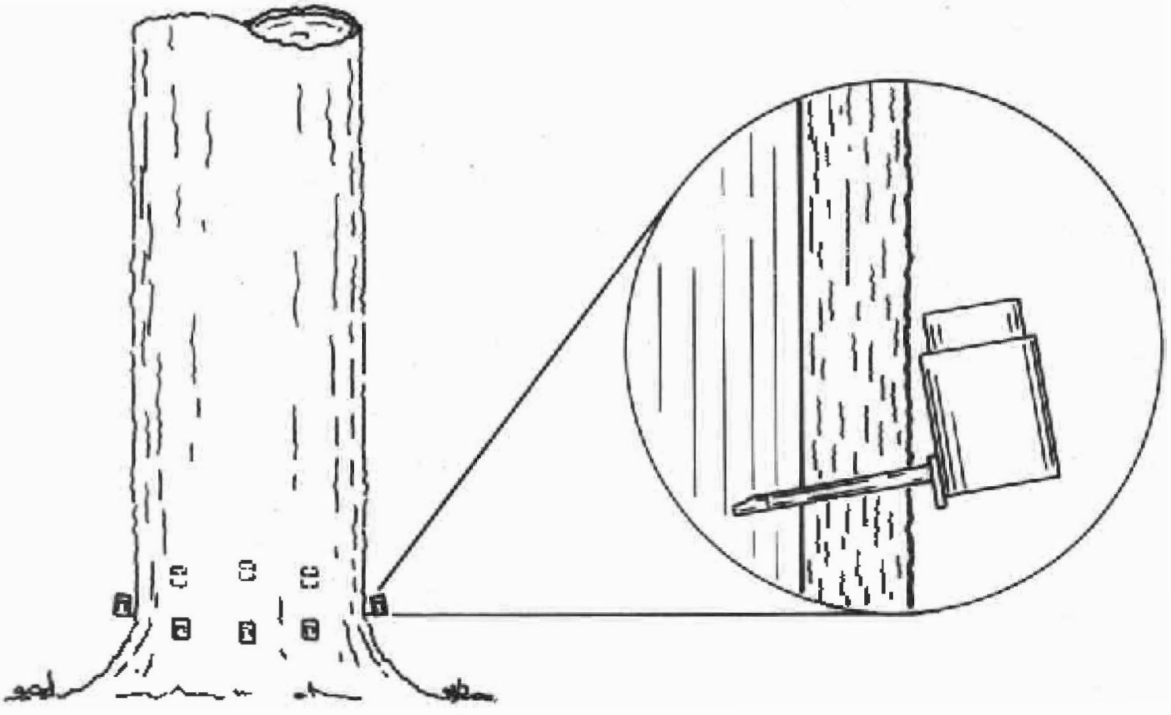

Figure 2. Placement of Inject-A-Cide injectors -- 6-inch spacing on circular pattern.

A final collection of 25 cones per tree, when possible, was made August 25 at Gardiner, August 27 at Wise River, and August 31 at Frenchtown. In the laboratory each cone was weighed and given a damage rating based on external appearance. The damage rating was one of the following:

Rating	Percent of cone injured
1	0
2	1-10
3	11-25
4	26-50
5	51-75
6	76-100

These cones were then pooled by tree number and air dried in paper sacks for several weeks. Seed from the dried cones were hand extracted, counted, and x-rayed (100 seeds per tree) to determine if the seeds were filled, hollow, or damaged (seed chalcids). At Frenchtown, some cones had already opened and some seed had been shed prior to collection. Hence, Frenchtown cones were not used in the seed analysis.

At Wise River, in addition to determining treatment effect on the cones, we also measured treatment effect on budworm-caused defoliation. Budworm populations at Gardiner and Frenchtown were too low to make a defoliation assessment. Defoliation was determined by cutting midcrown branch tips following cessation of budworm feeding and rating 25 new shoots on each of four branches per tree. Each shoot was given one of the following ratings:

Rating	Percent defoliation
1	0
2	0-25
3	26-50
4	51-75
5	100

Data analysis was at the tree level. Treatment means and standard errors were calculated. Analysis of variance was used to test for differences between treatment means. Student-Newman-Kuels tests at the .05 probability level were run to determine which treatments were different (Steel and Torrie 1960). A statistical package for the social sciences (SPSS) was used to perform these calculations (Nie et al. 1975).

RESULTS

No significant differences existed between tree diameter or height between treatments; diameter or height and total seed per cone, cone weight, or visual cone damage, and current defoliation gave no significant relationships for any treatment for any area (Appendices 1 and 2). This leads to the conclusion that treatment effect is not influenced by tree size within the range of tree sizes in this project.

The sample of small cones showed no differences in cone condition or rates of infestation for any treatment at any area (Appendices 3, 4, and 5). At Wise River and Frenchtown, from 85 to 95 percent of the cones were alive regardless of treatment. Of the live cones, 26 to 48 percent at Wise River and Frenchtown were either insect infested or showed evidence of insect feeding. A hard frost at Gardiner prior to the small cone sample killed about 80 percent of the conelets. From 55 to 59 percent of the cones that were not killed by frost were either insect infested or had feeding injury.

Treatment effects were first noticed by the greener appearance of the foliage of treated trees. Defoliation at Wise River (only area sampled) differed between all treatments (Appendix 6). Foliage protection was 74.3 percent for Acecap, and 56.7 percent for Inject-A-Cide.

Significant differences in visual damage of mature cones occurred at Wise River and Gardiner for both Acecaps and Inject-A-Cide (Appendix 7). At Frenchtown, only the Inject-A-Cide damage was different (Appendix 7). Failure of the Acecap at Frenchtown was probably due to slower uptake in combination with the late application.

Green cone weights from trees treated via Acecaps and Inject-A-Cide were significantly different from the control trees at both Wise River and Gardiner, but not at Frenchtown (Appendix 8). At Wise River, cone weights were increased by 70 to 72 percent, while at Gardiner the increase was between 56 and 60 percent. The weight gains at Frenchtown were not significant and were below 23 percent.

Seed yield per tree was obtained by dividing total seed count for each tree by the number of cones collected from that tree. Seed yields are tabulated below:

	Seed per cone[1] (number)			Yield increase (percent)	
Area	Acecap	Inject-A-Cide	Control	Acecap	Inject-A-Cide
Wise River	20.86	24.29	3.69	82.3	84.8
Gardiner	19.88	17.49	6.03	69.7	65.5
Frenchtown	Seed was not extracted or counted				

[1]All seed condition classes.

Seed per cone for both insecticide treatments at Wise River and Gardiner were significantly different from the control but not different from each other (Appendix 9). Overall seed yields were increased between 65 and 85 percent.

Seed condition, as determined by x-ray analysis, was cataloged into three condition classes: (1) full seed, (2) hollow seed, and (3) damaged seed. Damaged seeds were those infested with seed chalcid or other visible damage. Full seeds were those capable of germination. At Wise River, the treatment resulted in an increase in the percent of full seed, and hence a reduction in the percent of hollow seed (Appendices 10, 11 and 12). Seed condition at Gardiner showed no adverse effects. Stipe and Green (1981) report that seed condition and germination rates were not related to treatment when sprayed with acephate. Here we found a slight treatment benefit but more important there was no harmful effect on seed condition caused by acephate when implanted or injected.

DISCUSSION

Although evaluating the influence of treatment timing was not an objective of this project, some observations in this regard were made. Cone bud development was quite different at each area at the time of treatment. The buds at Wise River were very tight and pointed; at Gardiner buds were rounded and conspicuously swollen; while at Frenchtown the buds had burst and the ovulate flowers were conspicuous from the ground. Treatment effect appears to be slightly better at Wise River (tight buds (figure 3)) than at Gardiner (swollen buds),and much better at both Wise River and Gardiner than at Frenchtown (burst buds). It appears that since the Inject-A-Cide is a liquid formulation, its response time is a little better than powder formulation (Acecap). Where budworm is an important pest, early application is critical with either formulation.

For this project we found that reproductive buds were still tight at Wise River (approximately 5,500 feet elevation) in mid-April; buds were conspicuously swollen at Gardiner (approximately 5,000 feet elevation) in mid-April; and flower buds had burst at Frenchtown (approximately 3,000 feet elevation) by late April. Bud phenology could vary considerably from what we experienced depending on whether it is an "early" or "late" spring.

The time required for one person to treat a 12-inch diameter tree is about 15 to 20 minutes regardless of which treatment is applied. Approximate cost of materials for this project was $1 per Acecap ($10/12-inch tree), and $1.50 per Inject-A-Cide ($9/12-inch tree). Another visit is required about a week following treatment with the Inject-A-Cides to remove them from treated trees, whereas Acecaps remain in the tree, eventually being completely calloused over by new growth. Both treatments are considered very safe and environmentally acceptable. A slight risk exists with exposure from rupturing, dripping, or squirting of the Inject-A-Cide. Hence, rubber gloves and protective glasses should be worn when using this device.

Our observations show that acephate implanted or injected into a tree as a systemic insecticide can greatly improve seed yield and foliage production in western spruce budworm infested stands.

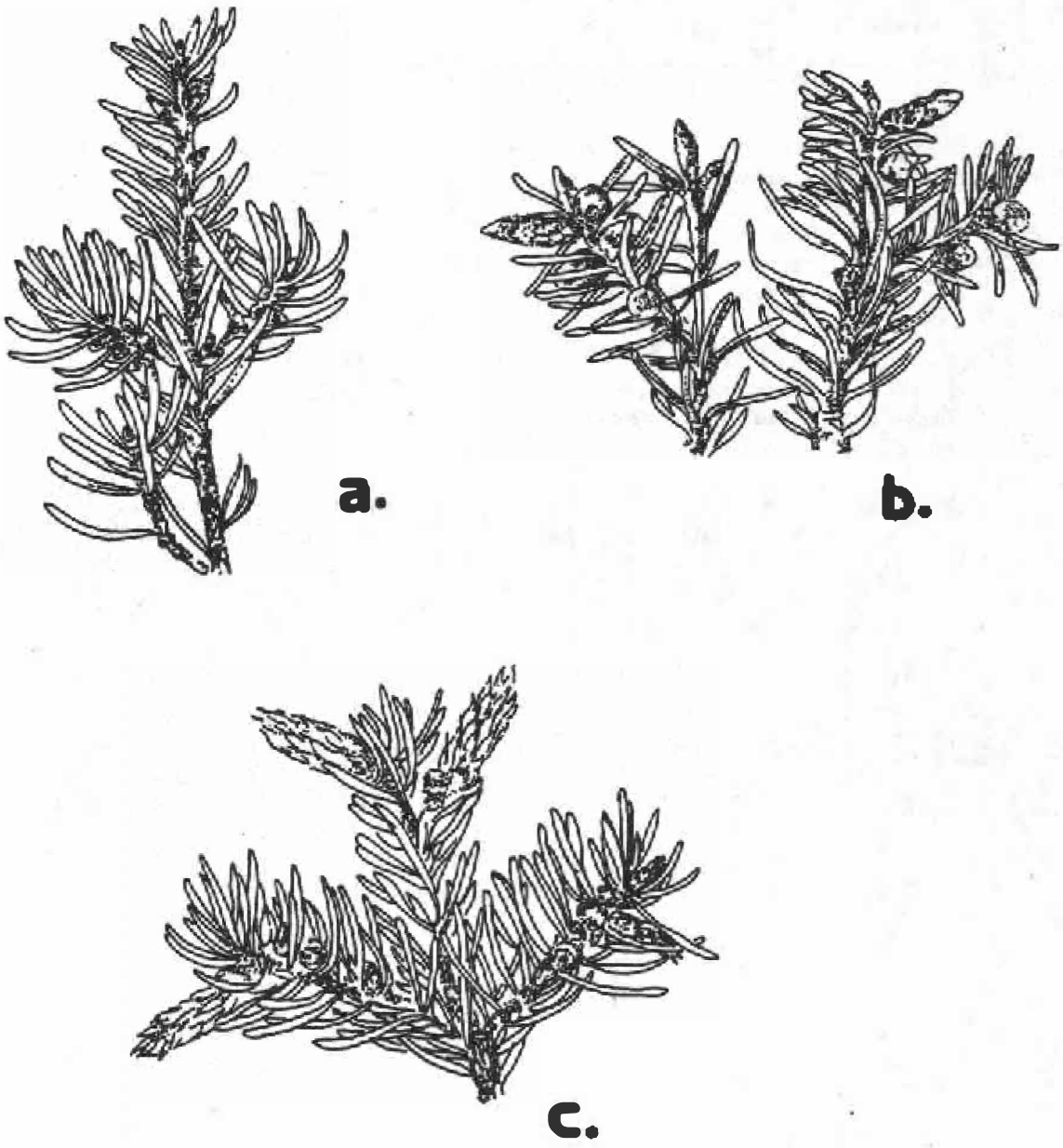

Fig. 3

Stages of bud development at times of treatment.

a. tight (Wise River)
b. swollen (Gardiner)
c. burst (Frenchtown)

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APPENDIX

Appendix 1. Analysis of variance and treatment means for tree diameter (in.) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	31.20	15.60	1.93	>.10
Error	37	298.37	8.06		
Total	39	329.57			

Acecap	12.70 a	Inject-A-Cide	13.06 a	Control	11.05 a	=.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	15.91	7.95	1.16	>.10
Error	51	347.33	6.81		
Total	53	363.24			

Acecap	11.05 a	Inject-A-Cide	9.80 a	Control	11.06 a	=.05

Frenchtown

Source	DF	SS	MS	F	P
Treatment	2	8.82	4.41	0.85	>.10
Error	47	244.76	5.21		
Total	49	253.58			

Acecap	8.38 a	Inject-A-Cide	9.53 a	Control	9.16 a	=.05

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 2. Analysis of variance and treatment means for tree height (ft.) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	201.09	100.54	1.84	>.10
Error	37	2015.28	54.46		
Total	39	2216.37			

Acecap	36.84 a	Inject-A-Cide	38.53 a	Control	33.21 a	=.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	81.91	40.95	1.03	>.10
Error	51	2014.17	39.49		
Total	53	2096.08			

Acecap	33.90 a	Inject-A-Cide	32.43 a	Control	35.55 a	=.05

Frenchtown

Source	DF	SS	MS	F	P
Treatment	2	183.68	91.84	2.22	>.10
Error	47	1944.49	41.37		
Total	49	2128.17			

Acecap	35.50 a	Inject-A-Cide	34.70 a	Control	31.10 a	=.05

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 3. Analysis of variance and treatment means for larvae per cone at Wise River, Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	0.40	0.20	2.61	.10> >.05
Error	37	2.84	0.07		
Total	39	3.24			

Acecap 0.49 a Inject-A-Cide 0.28 a Control 0.48 a =.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	0.11	0.05	2.13	>.10
Error	51	1.28	0.02		
Total	53	1.39			

Acecap 0.10 a Inject-A-Cide 0.05 a Control 0.16 a =.05

Frenchtown

Source	DF	SS	MS	F	P
Treatment	2	0.63	0.32	1.35	>.10
Error	47	11.11	0.24		
Total	49	11.74			

Acecap 0.39 a Inject-A-Cide 0.34 a Control 0.59 a =.05

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 4. Analysis of variance and treatment means for infested cones (%) Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	3511.42	1755.71	2.66	.10> >.05
Error	37	24428.57	660.23		
Total	39	27939.99			

Acecap 47.50 a Inject-A-Cide 26.78 a Control 45.35 a =.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	976.73	488.36	2.05	>.10
Error	51	12126.96	237.78		
Total	53	13103.69			

Acecap 9.75 a Inject-A-Cide 5.33 a Control 16.00 a =.05

Frenchtown

Source	DF	SS	MS	F	P
Treatment	2	982.51	491.25	0.92	>.10
Error	47	25053.73	533.06		
Total	49	26036.24			

Acecap 34.79 a Inject-A-Cide 29.41 a Control 39.32 a =.05

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 5. Analysis of variance and treatment means for aborted small cones (%) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	703.13	351.56	2.05	>.10
Error	36	6155.83	170.99		
Total	38	6858.96			

Acecap 8.75 a Inject-A-Cide 6.78 a Control 16.54 a =.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	805.88	402.94	1.86	>.10
Error	51	10996.42	215.61		
Total	53	11802.30			

Acecap 8.75 a Inject-A-Cide 3.91 a Control 13.75 a =.05

Frenchtown

Source	DF	SS	MS	F	P
Treatment	2	115.73	57.86	0.33	>.10
Error	47	8132.98	173.04		
Total	49	8248.71			

Acecap 8.58 a Inject-A-Cide 7.75 a Control 11.07 a =.05

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 6. Analysis of variance and treatment means for defoliation (%) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	19374.03	9687.01	51.96	<.01
Error	39	7270.52	186.42		
Total	41	26644.55			

Acecap 17.42 a Inject-A-Cide 29.30 b Control 67.75 c =.05

Gardiner

No samples

Frenchtown

No samples

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 7. Analysis of variance and treatment means for visual damage (%) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	21336.34	10668.17	37.56	<.01
Error	36	10223.11	283.96		
Total	38	31559.45			

Acecap	18.13 a	Inject-A-Cide	18.67 a	Control	67.15 b	=.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	12724.17	6362.08	12.46	<.01
Error	41	20922.83	510.31		
Total	43	33647.00			

Acecap	20.42 a	Inject-A-Cide	29.30 a	Control	59.12 b	=.05

Frenchtown

Source	DF	SS	MS	F	P
Treatment	2	2072.74	1036.37	5.56	<.01
Error	45	8390.81	186.46		
Total	47	10463.55			

Acecap	20.01 b	Inject-A-Cide	8.91 a	Control	23.16 b	=.05

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 8. Analysis of variance and treatment means for cone weight (gr.) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	328.63	164.31	23.89	<.01
Error	36	247.58	6.87		
Total	38	576.21			

Acecap	8.84 a	Inject-A-Cide	8.03 a	Control	2.44 b	=.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	181.19	90.59	8.32	<.01
Error	41	446.46	10.88		
Total	43	627.65			

Acecap	7.46 a	Inject-A-Cide	6.89 a	Control	3.00 b	=.05

Frenchtown

Source	DF	SS	MS	F		P
Treatment	2	16.23	8.11	2.97	.10	<.05
Error	45	122.98	2.73			
Total	47	139.21				

Acecap	4.38 a	Inject-A-Cide	5.53 a	Control	4.33 a	=.05

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 9. Analysis of variance and treatment means for seed per cone at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	3252.58	1626.29	21.65	<.01
Error	36	2703.95	75.11		
Total	38	5955.53			

Acecap 20.86 a Inject-A-Cide 24.29 a Control 3.69 b =.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	1692.46	846.23	6.59	<.01
Error	41	5257.69	128.23		
Total	43	6950.15			

Acecap 19.88 a Inject-A-Cide 17.49 a Control 6.03 b =.05

Frenchtown

No samples

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 10. Analysis of variance and treatment means for full seed (%) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	2603.68	1301.83	3.49	.05 > >.01
Error	34	12665.32	372.51		
Total	36	15269.00			

Acecap 27.46 ab Inject-A-Cide 35.01 a Control 14.43 b =.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	3134.72	1567.36	2.82	.10 >.05
Error	35	19444.69	555.56		
Total	37	22579.41			

Acecap 25.64 a Inject-A-Cide 36.59 a Control 48.39 a =.05

Frenchtown

No samples

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 11. Analysis of variance and treatment means for hollow seed (%) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	3807.34	1903.67	5.94	<.01
Error	34	10897.22	320.51		
Total	36	14704.56			

Acecap 61.71 a Inject-A-Cide 58.74 a Control 81.80 b =.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	1332.86	666.42	1.08	>.10
Error	37	22658.36	612.38		
Total	39	23991.22			

Acecap 70.16 a Inject-A-Cide 58.52 a Control 57.95 a =.05

Frenchtown

No samples

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

Appendix 12. Analysis of variance and treatment means for damaged seed (%) at Wise River, Gardiner, and Frenchtown.

Wise River

Source	DF	SS	MS	F	P
Treatment	2	326.98	163.48	1.61	>.10
Error	34	3433.09	100.97		
Total	36	3760.07			

Acecap	10.83 a	Inject-A-Cide	6.02 a	Control	3.77 a	=.05

Gardiner

Source	DF	SS	MS	F	P
Treatment	2	70.73	35.36	1.19	>.10
Error	37	1096.08	29.62		
Total	39	1166.81			

Acecap	4.26 a	Inject-A-Cide	4.90 a	Control	1.72 a	=.05

Frenchtown

No samples

Note: Means having nonsignificant differences at the 95 percent level based on Student-Newman-Kuels test are followed by the same lower case letter.

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